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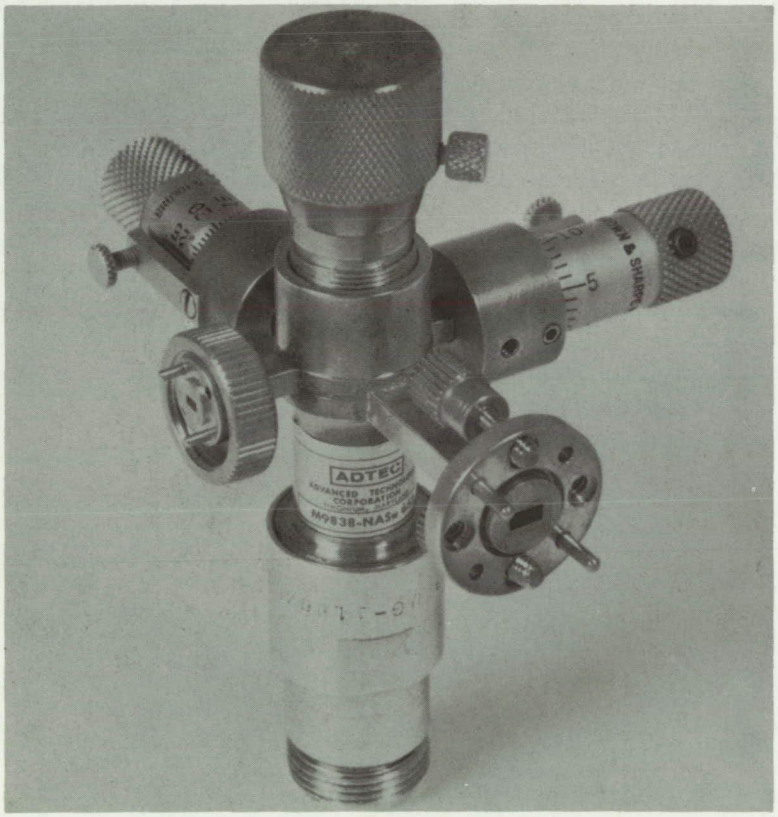
NASA TECH BRIEF

Efficient Millimeter Wave (140 GHz) Diode for Harmonic Power Generation



The problem:

To develop a varactor diode for efficient harmonic power generation (frequency multiplication) in the low-millimeter wavelength region of the electromagnetic spectrum.

For many years varactor diodes (reverse-biased p-n junction diodes) have been used to obtain microwave energy by harmonic multiplication from a lower radio frequency power source. Although a varactor pumped at some fundamental frequency is theoretically capable of producing an output at any desired harmonic with 100 percent efficiency, in practice, however, the conversion efficiency decreases rapidly with increasing fundamental frequency and desired harmonic number. As a consequence, commercially available varactors have in the past been limited in

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application to the frequency range up to and including X-band (5.2 to 10.9 GHz). More recently (September 1965), an output of 2 milliwatts at 60 GHz has been reported for a tripler (20 GHz input) at an efficiency of 2.5 percent. The frequency cutoff of the commercially available varactor diodes is still too low for efficient operation in the millimeter wave region.

The solution:

An epitaxial gallium arsenide diode junction formed in a crossed waveguide structure and operated as a variable reactance (varactor) harmonic generator. The efficiency realized with these diodes in doubling from 70 GHz (4 mm wavelength) to 140 GHz (2 mm wavelength) ranged from 20 to 30 percent. The highest output power obtained at 140 GHz was 16 milliwatts.

How it's done:

The diode is comprised of a 0.005-inch-thick epitaxial n-gallium arsenide wafer in contact with an electrolytically pointed zinc whisker. The epitaxial layer, 4.0 microns thick, had a carrier concentration of 5.9×10^{16} donors per cm^3 and a resistivity of 0.0422 ohm-cm. The substrate resistivity was 0.00049 ohm-cm. The gallium arsenide wafer is mounted on a 0.020-inch-diameter pin which is inserted in the RG-138/U guide by use of a differential screw control at the top of the structure. The zinc whisker is mounted on a 0.020-inch-diameter whisker carrier which is inserted through the RG-98/U guide and held in place by an N-connector. The contact between the zinc whisker and the gallium arsenide wafer is made by adjustment of the differential screw, and the junction is formed by electrical pulsing through the N-connector while the dc current-voltage curve is displayed. The pulsing is continued until a reverse breakdown voltage (–16 to –19 volts) occurs. The formed diode is biased in the reverse conduction region at –3 to –4 volts and carefully tuned until harmonic output (140 GHz) is detected by a calibrated bolometer.

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Headquarters
National Aeronautics and Space Administration
Washington, D.C. 20546
Reference: B67-10166

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Advanced Technology Corporation
under contract to
NASA Headquarters
(HQ-61)